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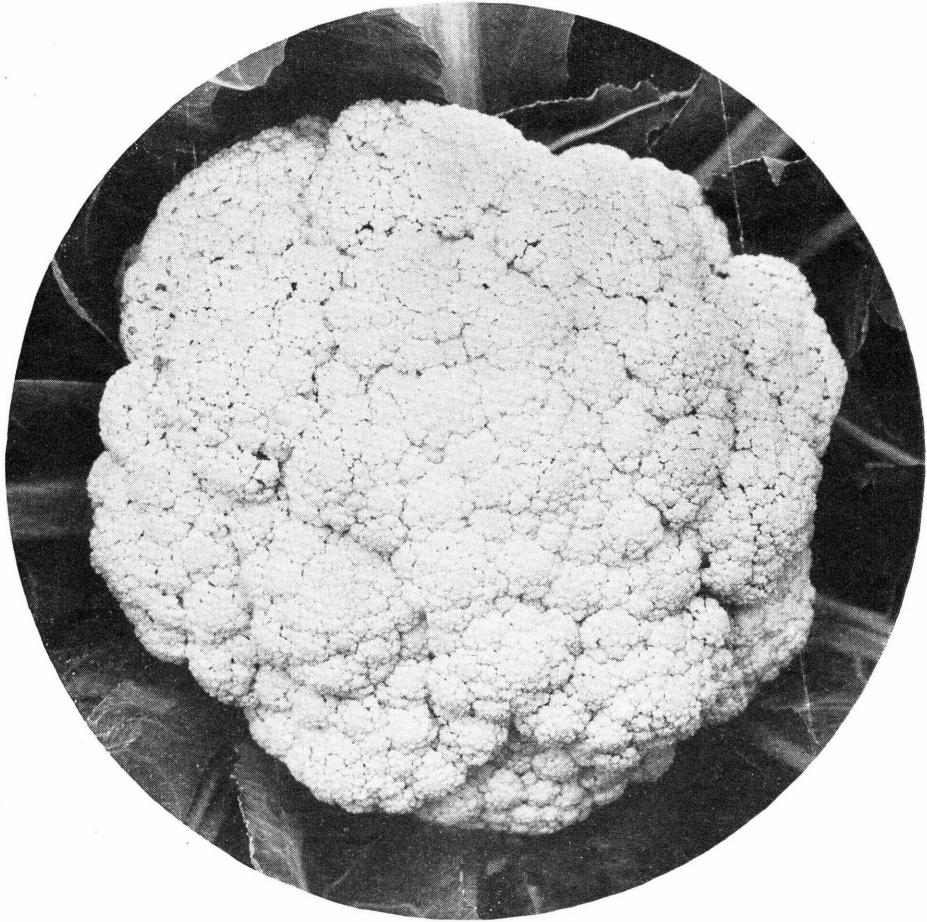
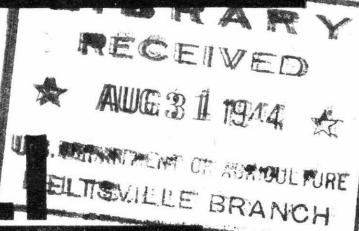
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CAULIFLOWER DE 1965

CAULIFLOWER

AND

BROCCOLI

VARIETIES AND CULTURE



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CAULIFLOWER is among the most difficult of the vegetable crops to grow successfully. On account of its exacting climatic and cultural requirements it is not well adapted for general home-garden culture. Broccoli is less exacting in its requirements; hence it is better adapted for the home garden. It can be grown successfully in many localities where cauliflower fails to make a crop.

Both cauliflower and broccoli are cool-season vegetables. Several important conditions must be met for profitable cauliflower production. These are soil of good fertility, rich in organic matter and high in nitrogen; general low temperature during the growing season, but freedom from frost; soil moisture at a fairly high level throughout the growing season; and a relatively high atmospheric humidity. These requirements limit commercial production to regions where the atmosphere is cool and humid because of latitude, elevation, or nearness to large bodies of water.

The conditions necessary for success with broccoli differ only slightly from those required for cauliflower; however, it is more tolerant of heat than cauliflower. This tolerance permits its production to extend into districts where the climate is too warm for cauliflower.

There are few plants for which seed of a good strain is so essential for a successful crop as cauliflower. Good cauliflower seed is difficult to grow and expensive. Formerly, most of the cauliflower seed used in the United States was imported from Denmark and the Netherlands. Improved methods of production have made it possible to produce good cauliflower seed in this country. The domestic production now exceeds the needs, and some is exported. Some of the strains developed here may prove to be better adapted than foreign seed.

Both cauliflower and broccoli are subject to some of the diseases and insects that attack cabbage and other cruciferous crops; hence they should not be grown in succession on the same land.

This bulletin supersedes Leaflet 130, Cauliflower and Heading Broccoli Production.

CAULIFLOWER AND BROCCOLI VARIETIES AND CULTURE

By ROSS C. THOMPSON, *horticulturist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration*

Contents

Page		Page	
Climatic adaptation and cultural requirements		Harvesting and packing broccoli	10
Cauliflower varieties	2	Insects and their control	11
Early to midseason varieties	3	Methods of using dusts and sprays	11
Late varieties	3	Cabbage caterpillars	12
Broccoli varieties	4	Cutworms	14
Soil and fertilizer needs	4	Cabbage maggot	15
Importance of good seed	4	Aphids, or plant lice	15
Growing the plants	5	Methods of controlling diseases	16
Transplanting to the field	6	Use of disease-free seed	16
Cultivation and irrigation	7	Seedbed sanitation	17
Blanching, harvesting, and packing cauliflower	7	Rotation	17
	8	Clubroot control	17
		Spraying	17

CAULIFLOWER, the so-called heading broccoli, and sprouting broccoli are all members of the cabbage group and therefore are closely related botanically. Heading broccoli, sometimes called cauliflower-broccoli, is in effect a late, long-season cauliflower. Sprouting broccoli may be described as a green-headed, elongated, branching form of cauliflower (fig. 1). The term "heading broccoli" as generally used is somewhat confusing, since both the plant and its head resemble those of cauliflower much more than those of sprouting broccoli. Few people would fail to distinguish heading broccoli from sprouting broccoli, but even a trained horticulturist might confuse heading broccoli with the late varieties of cauliflower.

The chief difference between varieties of cauliflower and those of heading broccoli is that the latter requires a longer time from planting to reach maturity. It seems more logical and less confusing to consider the varieties of heading broccoli as late, long-season varieties of cauliflower and to apply the term "broccoli" only to the sprouting form. In this bulletin, therefore, cauliflower will be used to include all the varieties of cauliflower and of the so-called heading broccoli, or cauliflower-broccoli. Broccoli will be used only for the sprouting form.

Cauliflower is grown as a commercial vegetable crop on some 30,000 acres in the United States. Up to about 1930 there was a steady increase in the acreage devoted to its production. Since then the plant-



FIGURE 1.—A head of broccoli ready to harvest.

Only within recent years has broccoli received much attention as a vegetable in America, although it has been grown in Europe for centuries. Recently it has become very popular in certain markets. Much broccoli is now grown in the Southern and South Atlantic States for shipment to northern markets; it is also grown in most of the cauliflower-growing States. The green heads of broccoli are a good source of vitamins and minerals. In this respect it is superior to cauliflower.

CLIMATIC ADAPTATION AND CULTURAL REQUIREMENTS

Cauliflower is one of the most difficult of the vegetable crops to grow successfully. Several very important conditions must be met for profitable production. They are soil of good fertility, rich in organic matter and high in nitrogen; general low temperatures during the growing season, but freedom from frosts; soil moisture at a fairly high level throughout the growing season; and a relatively high atmospheric humidity. Except under these conditions the crop is likely to be a failure. Commercial production of cauliflower is confined to districts where the atmosphere is cool and humid because of latitude, elevation, or nearness to large bodies of water. The importance of these factors is shown by the concentration of the industry in the coastal districts of California, on Long Island, N. Y., in the mountain districts of Colorado, and in western New York.

ings have remained fairly constant at about 30,000 acres. In 1941, when the acreage reached an all-time high of 32,100, the crop had an estimated farm value of about \$7,000,000.

The principal States producing cauliflower may be divided into three groups on the basis of the season at which the crop matures and is marketed. These groups are (1) fall and winter—California, Oregon, Arizona, and Texas; (2) early spring—California and Oregon; and (3) late spring or summer—New York, Colorado, New Jersey, Michigan, and Washington. Small acreages are grown in other States.

Broccoli is much less exacting in its requirements than cauliflower. It can be grown therefore in many places where cauliflower fails to make a crop.

Cauliflower and broccoli are attacked by many of the same diseases and insects that affect other members of the cabbage group; hence they should not be grown on land that has been planted to cabbage, turnip, kale, and related crops during the preceding 4 or 5 years.

CAULIFLOWER VARIETIES

There is a great deal of confusion in the names given to cauliflower varieties and strains. The origin of many is obscure. Some varieties that are not well fixed as to type are often sold under several names. Although there are 35 or more varietal names in use, there are probably not more than a half-dozen distinct varieties. The uniformity and heading ability of a strain are more important than its varietal designation.

One of the most important differences in strains of cauliflower is the period required for a crop to reach maturity. Some early strains of the Snowball type become marketable in 50 to 55 days after being transplanted to the field. Some midseason strains of the Danish Giant type require 70 to 80 days. Late types, which are grown mostly in the Pacific Coast States, may require more than 150 days.

Strains differ in the character of the foliage and in the manner in which the inner leaves enclose the developing curd and protect it from sunlight. Such protection is very important in districts where the crop matures during bright, sunny weather. Another important difference in strains is in the amount of leafiness in the head. Some strains have an undesirable tendency to develop small leaves that extend out through the branches of the head.

Some of the best of the cauliflower varieties are here described.

EARLY TO MIDSEASON VARIETIES

Super Snowball.—This is one of the earliest varieties, maturing 50 to 60 days from the date the plants are set in the field. It is a short-leaved type and more spreading in habit of growth than the true Snowball. Good strains of Super Snowball are uniform in growth and time of maturity so that much of the crop can be harvested at one cutting. The heads are medium in size, solid, and clear white. It is a favorite where earliness is important.

Snowball.—Although it is one of the older varieties, Snowball is one of the best and most widely adapted of the main-crop varieties. It matures a few days later than Super Snowball, requiring 60 to 65 days from date of field setting. Good strains are uniform in growth and maturity. The plants are of medium height and have broad, pale, grayish-green leaves which turn outward at the tips. The heads are medium in size, firm, ivory white, and of good quality.

Snowdrift.—This is one of the newer varieties, but it has gained rapidly in popularity. It is a good-shipping variety, maturing at about the same season as Snowball. Snowdrift is a sure-heading variety and is considered one of the best for preservation by freezing. The plants are a little larger than those of Snowball and have long erect leaves. The heads are larger than those of Snowball; they are solid, snow white; although free of leafiness, they are well protected by leaves during the early stages of development.

Dwarf Erfurt.—This is one of the older varieties and is less popular than formerly. It is midseason in maturity, requiring about 70 days from field setting. The plants are large and upright. The heads are medium to large, snow white, and fairly well protected by the inner leaves.

Danish Giant.—This is one of the largest and latest of the true cauliflower varieties, maturing 70 to 80 days from the time the young plants are set in the

field. It is also called Dry Weather because it is one of the most reliable headers under somewhat dry, adverse weather conditions. The plants are large and upright. The large leaves give the heads good protection from sunlight and frost. Danish Giant withstands cold better than most other varieties. The heads are very large and are snow white.

LATE VARIETIES

St. Valentine.—This is one of the best and most widely planted varieties for early-spring shipping. The plants are large with dark-green foliage. The heads are large, white, and well covered.

White Cape.—Although not so popular or so widely planted as St. Valentine, White Cape is a good home- and market-garden variety. The heads are medium to large, creamy white, and well protected.

Pacific coast strains.—On account of their long growing season some of the Pacific coast districts are better adapted for the growing of the long-season type of cauliflower than most other parts of the United States. Several strains of late-maturing cauliflower that are well adapted to the climatic and soil conditions of the cauliflower-growing districts of California have been developed. Some of the best of these are Christmas, March, April, Late Pearl, and Mission Special. These strains are adapted for planting to mature at different seasons. The planting dates range from June to November. They are adapted for succession planting in the order named. The Christmas strain is adapted for planting in June to mature during late December and early January. Late Pearl and Mission Special are the latest and are suitable for planting in late October and November for harvesting in April and May.

BROCCOLI VARIETIES

Most of the broccoli grown in the United States is of the Italian Green type commonly known as Calabrese. There have been developed strains of Italian Green that range from 70 to 150 days in the time required to reach marketable maturity after the plants are set in the field. A variety for each season is described.

Early Italian Green Sprouting.—This is the leading strain grown by shippers and market gardeners. It is the best strain for growing in the East, where the growing period is short, because the midseason temperatures are too high. It is a vigorous early variety forming a compact central head with few lateral branches. Under favorable growing conditions it reaches maturity in 70 to 80 days from date of field setting.

Midseason Green Sprouting.—This is similar to the early strain, but it requires 95 to 100 days to mature. It is adapted for planting on the Pacific coast and in the Southern States, but it requires too long a season for the cauliflower-growing sections of the Eastern States.

Late Green Sprouting.—The late strain requires 150 days or more to reach maturity. It is adapted for planting in sections of the Pacific coast with a long cool season and perhaps in parts of the South as a winter crop; it requires too long a season to be useful in the Northern States. The heads are large, of good quality, and almost free of lateral branches.

There are also purple varieties of sprouting broccoli, but they are not important.

SOIL AND FERTILIZER NEEDS

Cauliflower and broccoli can be grown successfully on many types of soil, but they reach their highest quality on fairly heavy soil of high water-holding capacity. Good crops can be grown on the lighter soils provided they are fertile and the plants are well supplied with moisture. Good drainage is essential but these vegetables, especially cauliflower, must not be permitted to suffer for want of water. The growth of the plant must be rapid and regular. Lack of moisture, poor

drainage, or any other unsatisfactory soil condition may upset the development of the plant and cause the premature formation of small heads, or "buttons."

Premature bolting in cauliflower has been shown to be associated with lack of nitrogen in the plant tissues. This emphasizes the importance of maintaining the nitrogen supply of the soil. On account of the importance of nitrogen it is desirable to use legume crops in the rotation with cauliflower and broccoli. If green-manure crops are used to maintain the soil humus, legumes should be used where they can be worked into the general farm plan.

In order to obtain the necessary rapid, vigorous growth of the plants the soil must be fertile. Barnyard manure is unsurpassed as a source of nutrients for cauliflower and broccoli where it can be obtained in large quantities at reasonable cost. As much as 30 tons per acre may be used on land for cauliflower production. Some commercial fertilizers are generally used to supplement the manure even where a large amount is applied. Where manure is not available the organic matter of the soil should be maintained by plowing under green-manure crops and the fertilizing elements should be supplied by commercial fertilizer.

Nitrogen is usually the element most needed in the production of these crops. This is especially true in the Western States. From 1,000 to 3,000 pounds of a complete fertilizer may be used profitably on land for cauliflower. The formula of the fertilizer and the rate of application should be determined largely by local conditions and the previous cropping and fertilizing of the land. In general, 10 to 15 tons of manure or a good growth of some green crop and 1,000 to 1,500 pounds of a complete fertilizer containing from 4 to 6 percent nitrogen, 8 to 10 percent phosphorus, and 5 to 7 percent potassium are needed. Supplementing these with one or two side dressings each of 150 to 200 pounds of nitrate of soda or sulfate of ammonia per acre will give good results.

Some of the less fertile soils in the Eastern States may require larger amounts of fertilizer for maximum yields. Even on fertile land cauliflower usually responds to side dressings of nitrate of soda or sulfate of ammonia. Nitrate of soda is preferable where the soil tends to be acid. If the soil is very acid it should receive an application of 1,500 to 2,000 pounds of lime per acre well in advance of the planting season.

Heavy fertilization may be less profitable in the production of broccoli than in the growing of cauliflower, since the return per acre may be less.

IMPORTANCE OF GOOD SEED

Seed of a good strain is more essential for the successful production of cauliflower than of most other plants. Prior to 1940 practically all the cauliflower seed planted in this country came from Europe, Denmark and the Netherlands chiefly. The annual requirement of cauliflower seed amounted to about 15,000 pounds. The cutting-off of commerce with European countries as a result of the war made it necessary to rely on domestic seed. Some work had already been done to determine the needs and the possibilities of producing good

cauliflower seed in this country. Efforts were increased after the outbreak of hostilities in Europe. As a result good cauliflower seed in excess of domestic needs is produced. The production of cauliflower seed reached approximately 52,000 pounds in 1942. Some of the new strains developed and selected here may prove to be better adapted, for at least some of the cauliflower-producing sections, than European seed grown and selected under conditions different from those prevailing in the United States. Much of the broccoli seed used in this country had been grown here before the war.

Good cauliflower seed, being difficult to grow, is high-priced. However, the small amount of seed required to grow enough plants to set an acre makes the cost of seed a relatively inexpensive outlay. The difference in cost between good and poor seed is more than compensated by the increase in yields to be obtained from high-grade seed of the best strains.

GROWING THE PLANTS

Dates for planting cauliflower and broccoli depend upon the locality, the length of time required to reach maturity, and the season during which it is desired that the crop mature. In California cauliflower is planted from May 15 to late November. As stated on page 4, in the various districts different varieties and strains are planted on the particular dates for which they are adapted. For information on the growing of cauliflower in California, the reader is referred to California Agricultural Extension Circular 93, Cauliflower Industry of California. In most of the eastern cauliflower-growing sections the season is too short for the long-season varieties and most of the crop is of the earlier short-season strains grown in either spring or late fall.

In the important cauliflower districts of California the climate is mild throughout the growing season and most of the plants for transplanting to the field are grown in open beds. In the eastern sections cauliflower and broccoli plants for the spring crop are started in hot-beds or greenhouses, while the fall crop is grown from plants started in outdoor plant beds.

Where cauliflower and broccoli plants for transplanting are grown in open beds the seed is planted, usually with a seeder, in rows 12 to 14 inches apart. In some localities the seed is broadcast. The chief objection to the broadcast method is that the soil cannot be properly cultivated to control weeds. The seed should be covered lightly with soil to a depth of a quarter to a half inch. One ounce of seed will produce about 3,000 plants, and about 3 ounces of seed are required to supply enough plants to set an acre. Most growers buy and plant much more seed than is necessary, when properly handled, for adequate supplies of plants.

Plants started under glass for the early crop are grown in flats, benches, or beds, either in rows or broadcast. The seed should be planted thinly so as to give the seedlings ample room to develop. When the seedlings have reached the four-leaf stage they should be pricked out, allowing about 2 inches between plants each way, and permitted to grow until field conditions are favorable for transplanting.

The soil for the growing of cauliflower and broccoli plants for transplanting should be a loose, friable loam but not excessively fertile. Soil that has a tendency to crust on the surface should be avoided.

Sometimes cauliflower, and frequently broccoli, is planted with seeders in the field where the crop is to be grown and the plants are thinned to the proper distance when they have reached a suitable size. The thinning should be done before the plants have reached such a size as to crowd. In some cases the planters are set to drop three or four seeds in place where the plants are to stand after thinning. When seeding in place is practiced, early thinning to prevent crowding and root injury to the plants left is very important.

TRANSPLANTING TO THE FIELD

Land for cauliflower and broccoli should be deeply plowed. The soil should be well pulverized by being thoroughly worked so that the surface soil approaches that required in good gardening.

In most of the important production centers cauliflower and broccoli plants are set in rows $2\frac{1}{2}$ to 3 feet apart. The distance between plants in the row varies greatly depending upon the variety or strain grown. Some of the smaller, upright-growing strains are set as close as 15 inches apart in the row. The late, large strains are set 2 to 3 feet apart in the row. The latter distances are used generally throughout the western sections.

Methods of transplanting differ in the various producing districts. In California and throughout the West in general the plants are set by hand on the side of an irrigation furrow. Some growers prefer to have water run through the furrows in advance of setting; others set the plants in dry soil and follow setting immediately by irrigation. In either case the irrigation that follows transplanting settles the soil firmly about the roots. After a week or 10 days the original furrow in which the plants were set is filled in and a new irrigation furrow is made midway between the rows.

In the eastern cauliflower- and broccoli-growing sections transplanting is done both by hand and by horse- or motor-drawn plant-setting machines. On small farms and in truck gardens transplanting is generally done by hand, but most of the large growers are able to employ setting machines. These are equipped to apply a small amount of water with each plant. Some of the machines are also equipped to distribute fertilizer.

Cauliflower is less hardy to cold than cabbage and should not be set in the field as long as there is danger of killing frosts. The stunting of cauliflower plants by cold tends to induce premature heading, and small unmarketable heads result. Broccoli is less likely to suffer from the effects of low temperatures after setting than cauliflower, but freezing weather should be avoided.

CULTIVATION AND IRRIGATION

Cultivation should be frequent enough to prevent weed growth and surface crusting. For either weed control or mulching the cultivation should be done with proper implements and should be shallow.

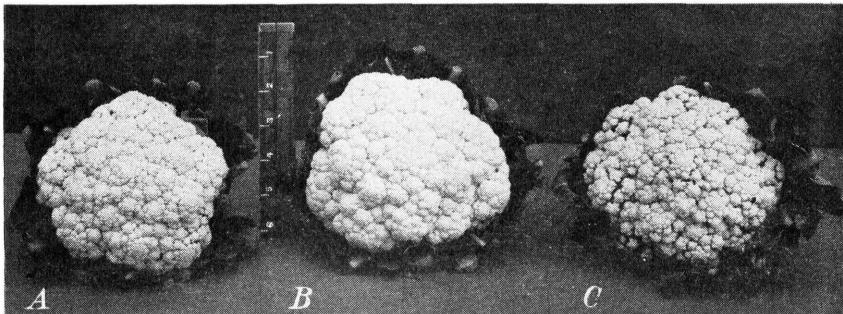


FIGURE 2.—Cauliflower heads showing three stages of maturity: *A*, Just past prime condition but still salable; *B*, in prime condition for marketing; *C*, "ricy," too old and unsalable.

Cultivation deep enough to cause frequent or severe root injury should be avoided, especially during the later stages of growth.

Except in districts where rainfall can be depended upon to be sufficient and properly distributed during the growing season to maintain the required moisture level for cauliflower, some provision should be made for irrigation.

The cauliflower plant will not produce a good commercial head if it is permitted to suffer for want of water. Broccoli can be grown under less favorable moisture conditions than cauliflower. Practically all the cauliflower and broccoli produced in the Western States are grown under irrigation. Much of the eastern crop is grown without any supplemental irrigation, and it is frequently injured by drought.

BLANCHING, HARVESTING, AND PACKING CAULIFLOWER

The heads, or curds, of cauliflower, when properly grown, are snowy white; the market demands a white product. When in prime condition for harvesting, they are fully developed, compact, and clear white, and they must be free of any discoloration or "riciness" (fig. 2, *B*). Cauliflower is not only unattractive but often develops an undesirable flavor if grown exposed to sunlight. Discoloration lowers the grade and consequently reduces the price. While they are still small the curds are well protected from the sun by the small incurved leaves surrounding the head. As the head enlarges the protecting leaves are forced apart, leaving the curds protected from light only by the large outer leaves. In some large, late varieties in which the leaves are very long and upright, the curds are fairly well covered and often no artificial protection is required, especially if the crop matures during cool weather. The developing heads of short-leaved and spreading varieties of the Snowball type are protected from sunlight by gathering the longest leaves together over the head and tying them with a soft twine, raffia, or tape (fig. 3). Because the plants do not all develop heads at the same time, it is necessary to go through the field every 2 or 3 days to tie each plant when the head begins to show through the small central leaves surrounding it. In order to have some convenient label on the plants tied at one time, a different-colored tying material may

be used for each tying date. If the tying is done regularly and when the heads are at the same stage of development, most of the heads tied with a given color of string on one date will be ready for harvest on the same date. This device eliminates unnecessary examination of tied plants that are not nearly ready for harvest.

After being tied, a few heads should be examined daily to make certain that they do not become overdeveloped. "Ricy" and "feathery" heads resulting from overdevelopment have little or no market value

FIGURE 3.—A cauliflower plant tied for blanching.



(fig. 2, C). On the other hand, there is danger of sacrificing size and weight if the harvesting is done prematurely. It is better to cut a little early than too late, for even slight overmaturity reduces quality (fig. 2, A). The most desirable size is about 6 inches in diameter. Unless the plants are large and have made a good vigorous growth, large heads cannot be obtained by delayed harvesting. The time required for the heads to reach the proper stage of maturity after they are tied depends very largely upon the temperature. If the temperature is high, less time will be required than if it is low. In warm weather cauliflower may reach marketable maturity within 3 to 5 days after being tied, but in cool weather, when the growth rate is slow, as much as 2 weeks may elapse before the heads are ready to harvest. The grower should learn to judge the maturity of the cauliflower head by its appearance rather than depend entirely upon size or time elapsing from date of tying.

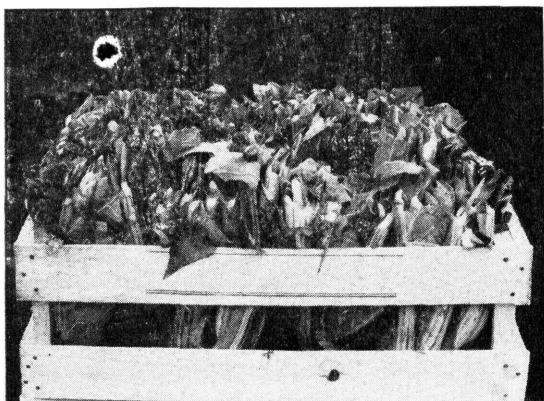
At harvest cauliflower heads are cut from the plant with a large knife, leaving one or more whorls of leaves attached to protect the curds. In the large production districts the cut heads are usually hauled to a central packing shed, where they are graded, trimmed, and packed, usually in crates. In some districts the packing is done in the field.

Various sizes and shapes of containers are used for shipping. Most of the western cauliflower crop is shipped in the pony, or flat, crate holding one layer of heads. New York growers also use a one-layer pony crate, but other kinds of containers are in general use. Four-basket tomato crates, egg and orange crates, bushel baskets, and other types of containers are often used for short hauls and local markets.

Where the flat, or pony, crate is used, the heads with a few leaves attached are packed erect in the crates and the foliage is then cut off with a large knife, leaving a bulge of about 2 inches at the center (fig. 4). Regardless of the type of container the leaves are usually cut off just above the head, leaving a jacket of petioles and part of the leaf blades to protect the head.

HARVESTING AND PACKING BROCCOLI

FIGURE 4.—A crate of cauliflower trimmed and ready to be lidded.



Unlike cauliflower, broccoli requires no blanching; hence tying to protect the heads from light is unnecessary. Overmaturity reduces or destroys the commercial value of broccoli; therefore it should be cut before the flower heads have opened enough to show the yellow petals (fig. 1). Overmaturity also tends to cause a wood-

iness of the outer tissues of the stems, which is very undesirable. When the heads have reached the proper stage they should be cut with 8 to 10 inches of the stems. The cut heads and stems are usually tied in bunches in a manner similar to bunched asparagus and packed in crates, hampers, or other suitable containers. A crate in common use in New York measures 13½ by 22 by 10 inches and holds 18 bunches. Hampers are in general use in the South.

A second cutting of broccoli is sometimes obtained from lateral shoots that develop after the central flower cluster has been removed at the first cutting. While the central cluster of flowers may measure 3 to 6 inches at the proper stage of maturity the laterals develop much smaller clusters, measuring from 1 to 3 inches in diameter. The lateral heads may be bunched together or combined with central clusters maturing at the same time; however, the small lateral clusters are not so desirable as the large central ones and their inclusion with the latter may reduce the market value of the bunches.

INSECTS AND THEIR CONTROL¹

Cauliflower and broccoli are attacked by many kinds of insects, the most important of which are several species of cabbage caterpillars, cut-worms, the cabbage maggot, and aphids, or plant lice.

METHODS OF USING DUSTS AND SPRAYS

Dusts and sprays can be more effectively applied during calm periods of the day, which in many cases occur in the early morning or late afternoon. Spray applications will not be affected by wind as much as dust applications. Dusters equipped with a cloth trailer from 10 to 15 feet long will aid materially in reducing the drift of the dust, thereby providing a better coverage of the plant. The main objective in making either spray or dust applications should be to cover thoroughly all parts of the plant with the insecticide. Experience has shown that dust mixtures applied in the early morning or late afternoon are more effective than applications made during other periods of the day. Pyrethrum dust appears to be more effective when applied in the afternoon. The influence of these periods of the day on the degree of control effected can probably be attributed to the feeding habits of the insect, temperature, and moisture, as well as to wind movement.

The rate of applications of dust mixtures will vary with the equipment, the size of the plants, and the type of the material; but, in general, where the application is made with traction or power dusters, from 15 to 20 pounds of the dust mixture per application per acre is needed. When hand dusters are used for plants that are small enough to permit the application of dust to each plant individually, the rate per acre should be approximately 10 to 12 pounds. Spray mixtures should be applied at the rate of 100 to 125 gallons per acre with traction or power equipment; with hand equipment the rate should range from 50 to 60 gallons per acre when plants are in the early stages of growth.

¹ Prepared in the Division of Truck Crop and Garden Insect Investigations, Bureau of Entomology and Plant Quarantine, Agricultural Research Administration.

Applications of insecticides should be made at regular intervals; the first treatment should be made when the worm infestation reaches an average of approximately one worm per plant or when 25 percent of the plants in the field show signs of worm feeding. If the infestations continue to develop, treatments should be made every 10 days.

CABBAGE CATERPILLARS

The principal species of caterpillars that cause damage to cauliflower and broccoli are the cabbage looper (*Autographa brassicae* (Riley)), the diamondback moth (*Plutella maculipennis* (Curt.)) (also known as the cabbage plutella), the imported cabbageworm (*Pieris rapae* (L.)) (also known as the common cabbageworm), the cabbage webworm (*Hellula undalis* (F.)) (or budworm), the corn earworm (*Heliothis armigera* (Hbn.)) (also known as tomato fruitworm and bollworm), and several species of cutworms. Several other species, including the cross-striped cabbageworm (*Evergestis rimosalis* (Guen.)), sometimes occur in injurious numbers in certain areas. All these caterpillars are the immature stages of moths or butterflies.

The following recommendations are made for the control of caterpillars on cauliflower and broccoli during the existing wartime emergency. They provide for the minimum use of such scarce insecticides as rotenone and pyrethrum and are also designed to avoid a harmful residue hazard on the marketed product.

Control on Small Plants in Plant Bed and Field

To prevent damage to young plants in the plant bed or in the field and to reduce the possibilities of damage during the heading period, either calcium arsenate, cryolite, paris green, or barium fluosilicate should be used as a dust mixture or as a spray at least every 10 days up to the time when the plants have been set in the field, and after that for approximately 3 weeks if the caterpillars are present in damaging numbers, that is, an average of more than about one caterpillar per plant. These control measures are directed principally against the cabbage caterpillars, including the corn earworm and climbing cutworms. The control methods for soil-inhabiting cutworms are discussed on page 14.

In the dust form, calcium arsenate should be applied undiluted; cryolite diluted with equal parts of talc; paris green diluted with 9 parts, by weight, of hydrated lime; and barium fluosilicate diluted at the rate of 3 parts to 1 part of talc, by weight.

In the spray form, calcium arsenate, cryolite, and barium fluosilicate should be used at the rate of 2 to 3 pounds, and paris green at the rate of $\frac{1}{2}$ pound, to 50 gallons of water.

If applications of these arsenical or fluorine compounds do not provide entirely adequate control of the climbing cutworms or the corn earworm, a bait composed of 10 percent of cryolite and 90 percent of corn meal, by weight, mixed and used dry, should be sprinkled into the buds of the plant at the rate of about 25 pounds per acre any time during the period until the plants have been set in the field for approximately 3 weeks.

To avoid a harmful residue hazard on the marketed product, arsenicals or fluorine compounds, such as calcium arsenate, paris green, lead arsenate, cryo-

lite, or barium fluosilicate, should not be applied to cauliflower or broccoli after the plants have been in the field for approximately 3 weeks.

Calcium arsenate, paris green, cryolite, and barium fluosilicate are poisonous and should be handled with care and stored where children and domestic animals cannot reach them. Especial care should be taken, in mixing or applying these insecticides, not to inhale excessive quantities. Well-designed respirators affording protection to the entire face should be used whenever available. Wash the hands or other exposed parts of the body thoroughly after working with these compounds.

Control on Larger Plants

For the control of the green-colored caterpillars on cauliflower or broccoli after the plants have been in the field for approximately 3 weeks, it is recommended that rotenone-containing dust mixtures or sprays be applied at least every 10 days throughout the period, if there is an average of more than one caterpillar per plant.

Rotenone dust mixtures should contain from 0.5 to 1 percent of rotenone derived from derris, cube, barbasco, tuba, or timbo. They may be obtained in a ready-mixed form from dealers or they may be prepared by mixing the finely ground root of the above-named materials with such nonalkaline and finely ground diluents as talc, pyrophyllite, sulfur, or tobacco dust. For example, to prepare a dust mixture containing 0.5 percent of rotenone from ground derris root which contains 5 percent of rotenone, mix 10 pounds of the root with 90 pounds of the diluent. Rotenone sprays should contain 0.025 percent of rotenone. For example, a ground root containing 5 percent of rotenone should be used at the rate of 2 pounds to 50 gallons of water, to which should be added a nonalkaline spreader or sticker, such as a mild soap, a miscible or sulfonated oil, or one of the proprietary compounds designed especially for this purpose. Sprays made from extracts of derris, or of the other roots mentioned, may also be used. They should be prepared according to the directions of the manufacturer.

If rotenone-containing dust mixtures or sprays are not available, pyrethrum is recommended as a substitute in the form of a dust or as a spray. This insecticide is effective against the cabbage looper but is less effective than rotenone against the imported cabbageworm, the diamondback moth, and the cabbage webworm. Pyrethrum dust mixtures should contain at least 0.2 percent of total pyrethrins. These mixtures are usually available in a ready-mixed form from dealers, or they may be prepared by mixing finely ground pyrethrum flowers with such nonalkaline and finely ground diluents as talc, pyrophyllite, sulfur, or tobacco dust. For example, if the pyrethrum flowers contain 1.3 percent of total pyrethrins, the dilution should be at the rate of approximately 15 pounds of this material to 85 pounds of the diluent. The incorporation of 20 pounds of sulfur in 100 pounds of the mixed dust as part of the diluting material improves the effectiveness and stability of pyrethrum dust mixtures. Pyrethrum sprays should contain 0.006 percent of total pyrethrins. For example, finely ground pyrethrum flowers containing 1.3 percent of total pyrethrins should be used at the rate of 2 pounds to 50 gallons of water, to which may be added one of the nonalkaline spreaders or stickers mentioned for rotenone sprays. Sprays made from extracts of pyrethrum, or with combinations of rotenone and pyrethrum extracts, may also be used at dilutions recommended by the manufacturer.

Cultural Control Measures

To reduce caterpillar damage and the need for insecticides, the following practices are recommended. After harvesting has been completed in a field the crop remnants should be plowed under or otherwise disposed of. If this is not done the field serves as a breeding place for cabbage caterpillars to develop and infest other plantings. The rows should be planted to a uniform width in order to permit the effective adjustment and manipulation of spraying and dusting equipment. The plants in the row should be uniformly spaced to prevent crowding and a consequent poor distribution of the insecticide.

CUTWORMS

Cutworms sometimes are very destructive to cauliflower or broccoli plants directly after these have been transplanted from the plant bed to the field. These pests can be controlled readily by the use of the following poisoned bait: 1 peck (or 5 pounds) of dry bran, $\frac{1}{4}$ pound of sodium fluosilicate (or paris green), and 3 or 4 quarts of water; or, in large quantities, 25 pounds of dry bran and 1 pound of sodium fluosilicate or of paris green.

To prepare the bait: (1) Thoroughly mix the poison with the bran. This is important. Each particle of bran must carry a little poison to get a good kill. When making small quantities, one can mix the bait in a bucket with a paddle, adding the poison slowly and stirring the bran at the same time. When making large quantities, mix the poison with the bran on some flat, smooth surface; use a shovel and rake in much the same way as in mixing concrete. (2) Add the water to the mixture of bran and poison, stirring slowly all the time. Large quantities of water added at one time will wash the poison from the bran and the result will be an uneven mixture.

Add only enough liquid to make a crumbly mass. It is a good plan to set aside a little of the mixture of dry bran and poison so that if too much water has been used this dry reserve can be added to bring the mixture up to the proper consistency. Large quantities can be made up in galvanized-iron or wooden washtubs and small quantities in buckets or similar containers.

Either broadcast the poisoned bait or sow it by hand along the rows or about the base of the plants. Do this late in the evening so that the bait will not dry out to any great extent before the worms get busy. Since many kinds of cutworms overwinter in the ground and start feeding as soon as the weather becomes favorable in the spring, it is a good plan to broadcast the poisoned bait over the field before the plants are set.

Ten to fifteen pounds of the wet bait per acre is enough for one application. Where the bait is applied directly to the rows or hills a smaller quantity is sufficient. It may require two or three applications at 2-day intervals to rid the field of the pests.

A stomach poison for an insect is poisonous also to other animals and man. Keep the poison and poisoned-bran bait away from farm animals. Destroy all bait left over, and thoroughly clean all vessels and utensils used.

CABBAGE MAGGOT

Cauliflower, broccoli, and related crops often suffer badly from the attacks of the cabbage maggot (*Hylemya brassicae* (Bouché)), the young of a small fly which resembles the ordinary housefly. The eggs are laid around the roots of young plants when they are first set; and the newly hatched maggots, by gnawing off the outer surfaces of the stems and boring into the larger roots and the lower part of the stalks, seriously injure the young plants. When very numerous, the maggots are difficult to control, but relief may usually be obtained by applying corrosive sublimate (mercuric chloride) or calomel according to the following directions.

Corrosive sublimate, when used as recommended, will not poison plants or render them unfit for consumption. To prepare the solution for use against the cabbage maggot, dissolve one-half ounce (thirty 7.5-grain tablets as ordinarily sold at drug stores) of corrosive sublimate in a pint of hot water in a glass or earthenware vessel. Dilute to 5 gallons, which will be sufficient to treat from 200 to 300 plants. Apply soon after the plants are set and again about 7 to 10 days later, pouring half a teacupful of the solution over the soil and at the base of each plant.

Calomel may be used instead of corrosive sublimate for the control of this pest. Its use is especially recommended for plant beds of cauliflower and broccoli. Apply a liquid mixture composed of 1 ounce of calomel in 10 gallons of water to the base of the plants in the plant bed soon after they appear above ground, and repeat at 7- to 10-day intervals until four treatments have been applied. For plants in the field pour one-half teaspoonful of the mixture around the base of each plant soon after setting it and repeat 7 to 10 days later; this rate is equivalent to 1 gallon per 1,500 linear feet of row. To prepare this mixture, make the required quantity of calomel into a paste and then add it to the water. Keep the mixture well stirred at frequent intervals to prevent the settling of the calomel. Calomel can be applied as a dust mixed with gypsum (land plaster) or any similar inert carrier, at the rate of 1 pound of calomel to 24 pounds of the carrier. Apply around the base of the plant in the field or in the plant bed in the same manner as when using the liquid mixture. At the time of transplanting seedlings, they may be protected by dipping the entire root and stem in a heavy liquid mixture of 8 ounces of calomel per 10 gallons of water or by applying the undiluted calomel powder to the moistened stem of the seedlings before setting them.

Corrosive sublimate is very poisonous and must be handled with proper care. Calomel is not generally regarded as dangerously poisonous, being commonly used in small doses as a purgative. It should be stored, however, in labeled containers out of the reach of children and irresponsible persons, since excessive doses are poisonous.

APHIDS, OR PLANT LICE

Turnip and cabbage aphids are similar tiny, soft-bodied, sucking insects that can be controlled by insecticides such as nicotine sulfate or rotenone but cannot be controlled by stomach poisons. As in controlling all insects, it is especially important to start treatments as soon as the first infestation is evident. Controlling the first light at-

tack is usually not very difficult; but if control measures are neglected until cauliflower or broccoli is heavily infested, the damage may be serious and control measures will be of doubtful success. The infested leaves soon crumple and curl downward around the insects so that it is difficult to reach them with dust or spray.

The first few scattered infestations of the turnip aphid (*Rhopalosiphum pseudobrassicae* (Davis)) or the cabbage aphid (*Brevicoryne brassicae* (L.)) in a field can often be cleaned up by applying a 3-percent nicotine dust to the infested plants with a hand-operated duster. If the field includes more than 2 or 3 acres and the infestation is general, horse-drawn or power dusters or sprayers can be used more effectively. The field may be sprayed with a nicotine sulfate and soap solution made as follows: Three-fourths pint of nicotine sulfate (40 percent nicotine), 2 pounds of soap, and 50 gallons of water. About 100 gallons of spray solution is required per acre for a uniform application. From 30 to 40 pounds of dust per acre is needed. If the plants are small or if only small infested areas are to be treated correspondingly smaller quantities of material will be required.

Nicotine is poisonous and should be handled according to the directions on page 13.

A derris or cube dust mixture containing 0.5 percent of rotenone, made by diluting the ground root with equal parts of finely ground tobacco dust and sulfur, is also recommended for the control of the turnip aphid. Good results in controlling this insect have been obtained also with a rotenone spray consisting of 2 pounds of finely ground derris or cube root (containing from 4 to 5 percent of rotenone) to 50 gallons of water.

Dusts or sprays containing rotenone are not so effective as nicotine, however, in combating the cabbage aphid.

METHODS OF CONTROLLING DISEASES²

The diseases of cauliflower and broccoli, which are common to cabbage, are described in detail in Farmers' Bulletin 1439, Diseases of Cabbage and Related Plants. Those which affect these two crops most seriously are mosaic, black rot, blackleg, clubroot, damping-off, and ring spot. Since varieties resistant to any of these diseases are not available, the approach to their control is through preventive measures.

USE OF DISEASE-FREE SEED

Blackleg and black rot organisms are carried on and in the seed. Since the opening of World War II most of the seed of cauliflower and broccoli has been grown in Pacific coast districts where these two diseases do not affect the seed plants. Where the grower cannot be sure of the source of the seed, the germs may be removed by seed treatment. Treatment with mercuric chloride or with fungicidal dusts is not adequate to control blackleg and black rot. The only known effective treatment is the use of hot water. Seed is placed in very loose muslin bags and inserted in a constant-temperature bath at 122° F. for 30 minutes. If seed is old or weak, the germination will be reduced by

² Prepared by J. C. Walker, plant pathologist, Wisconsin Agricultural Experiment Station, Madison, Wis., and agent, Division of Fruit and Vegetable Crops and Diseases.

this treatment; therefore it is necessary to make a preliminary run on each seed lot to determine whether it will stand the treatment. Because of this treatment hazard, seed from the Pacific coast is far preferable to treated seed. Dusting the seed with Semesan may help germination somewhat. However, it is not a substitute for the hot-water treatment. The latter must be used if any seed grown east of the Rocky Mountains is to be safe from blackleg and black rot organisms.

Copper dusts should not be used on any cruciferous seed.

SEEDBED SANITATION

Most of the germs of the diseases mentioned on page 16 live over in the soil. Repeated use of the same soil in coldframes or seedbeds of any type is unwise. Outdoor seedbeds should be rotated, and soil in hotbeds or coldframes should be treated by one of the standard methods. The mosaic viruses live over in cruciferous weeds and some other plants from which they are carried to the seedbed by aphids. Placing of seedbeds near weedy borders should be avoided, and coldframe areas should be kept free from weeds. In areas near the Pacific coast where ring spot is severe, prompt cleaning up of cabbage, cauliflower, and broccoli refuse is necessary, since from it are discharged air-borne spores which may be carried long distances by air currents.

ROTATION

Blackleg, black rot, ring spot, and damping-off germs live 2 or 3 years in old cabbage refuse, and at least a 3-year rotation is advisable. The clubroot organism, once introduced, will survive indefinitely in a soil favorable to it. Therefore, if it is known to be present special control measures must be taken.

CLUBROOT CONTROL

Never use plants from a seedbed showing clubroot on the plants. It is not possible to sort out clean plants; an attempt to do so merely assures general distribution of the organisms over the transplanted field. When clubroot becomes established, it is best to avoid the area for crucifers indefinitely. If this cannot be done, the disease may be reduced by heavy applications of hydrated lime sufficient to make the soil slightly alkaline. This procedure may not eliminate the disease, but it will probably reduce it to minor importance. Heavy liming may bring on boron deficiency to which cauliflower is very susceptible; it is therefore well to apply 20 to 40 pounds of borax per acre for each crop when the soil reaction is neutral or alkaline.

SPRAYING

No cabbage diseases lend themselves to control by fungicidal sprays. However, the spread of mosaic is dependent on aphids and, since cauliflower and broccoli are very susceptible to mosaic, it is extremely important to start aphid control early and keep it up.

